Flight Instructor Training Module

For Inclusion in FAA-Approved Flight Instructor Refresher Clinics

Volume 3: System Safety Course Developers' Guide, Part II

Flight Standards Service

General Aviation and Commercial Division, AFS-800

Table of Contents

Foreword

System safety in the modern flight-training environment encompasses four key principles; risk management, aeronautical decision-making, single pilot resource management, and situational awareness. In *Volume 1: FAA/Industry Training Standards*, you were introduced to the system safety methodology as it applies to technically advanced aircraft. While the pilots of such aircraft will most certainly benefit from this approach to flight training, system safety concepts are equally at home in the cockpit of any aircraft, regardless of its sophistication or intended use.

Volume 2: System Safety Course Developers' Guide provided a more generic introduction to system safety. It also highlighted several practical tools for use in identifying hazards, assessing risks, and addressing safety-of-flight issues before they pose a threat. This *Flight Instructor Training Module*, the third in a series of new instructional resources, is designed to guide instructors through the process of developing their own unique scenario-based training programs. This will allow them to teach system safety not as an *ad hoc* instructional topic, but instead as an integral part of their training activities.

System Safety Terminology

Exposure: The number of personnel or resources affected by a given event or, over time, by repeated events.

Hazard: A real or potential condition, event, or circumstance that could lead to or contribute to an unplanned or undesired event. A hazard exists in the present.

Mishap: An unplanned event, or series of events, that results in death, injury, occupational illness, or damage or loss of equipment or property.

Probability: The estimate of the likelihood that a hazard will cause a loss (frequent, likely, occasional, seldom, unlikely).

Process: A set of tasks, workflows, and information flows that produce a desired result. A process defines how work is done, how results are achieved, and how value is provided.

Risk: An expression of the impact of an undesired event in terms of event severity and event likelihood. A risk exists only in the future.

Risk analysis: Involves developing a preliminary hazards list; creating a risk statement, determining the extent of hazard, estimating likelihood and severity.

Risk assessment: The process of identifying hazards and quantifying or qualifying the degree of risk they pose for exposed individuals, populations, or resources. This process involves sorting, combining, prioritizing risks and documenting priorities/risk information.

Risk control measures: Specific strategies that reduce, mitigate, or eliminate one or more of the three risk components (probability of occurrence, severity of hazard, exposure of people and equipment).

Risk management: Iterative activity ensuring that risk is identified and eliminated or controlled within established program risk parameters. The four basic principles of risk management are: (a) accept no unnecessary risk; (b) make risk decisions at the appropriate level; (c) accept risks when benefits outweigh costs; and (d) integrate risk management into planning at all levels. Levels of risk management include time critical, deliberate, and strategic.

Safety: The freedom from those conditions that can cause death, injury, or illness; damage to/loss of equipment or property, or damage to the environment.

Safety decision process: Involves five steps: (a) accurately identify hazards; (b) assess risk involved; (c) determine if risk is acceptable; (d) determine if risk can be eliminated; and (e) look for ways to reduce risk.

Severity: An estimate of the extent of loss that is likely (catastrophic, critical, marginal, or negligible).

Simulation: The use of animation and/or actual representations of aircraft systems to faithfully replicate the flight environment.

Single Pilot Resource Management (SRM): The “art and science” of managing all available resources, thus ensuring the successful completion of a flight.

System: The combination of people, procedures, equipment, facilities, software, tools, materials that operate in a specific environment to perform a specific task or achieve a specific purpose.

System safety: The application of special technical and managerial skills to identify, analyze, assess, and control hazards and risks associated with a complete system (i.e. a typical flight). System safety is applied throughout the system’s entire lifecycle (i.e. preflight to tie-down) to achieve an acceptable level of risk within the constraints of operational effectiveness, time, and cost.

Technically Advanced Aircraft (TAA): A general aviation aircraft that contains a global positioning system (GPS) navigator with a moving map display, plus any additional systems. Traditional systems, such as autopilots, are included when combined with GPS navigators. Aircraft used in both visual and instrument flight rules operations, with systems certified for either VFR or IFR flight, are also included.

Introduction

Similar to the FAA/Industry Training Standards, or FITS program discussed in *Volume 1* of this series, the goal of system safety integration is to modernize the current flight-training paradigm. This will occur through the introduction of risk management, aeronautical decision-making, single pilot resource management, and situational awareness within the general aviation (GA) community. While these concepts are central to all aeronautical activities, guidance is lacking on how best to introduce these topics to students during all phases of training. Equally daunting is the task of developing formalized, yet practical risk management tools for use by all pilots, regardless of their experience level.

To meet the challenge of introducing system safety to all GA pilots, the Federal Aviation Administration (FAA) has developed this training module. Not only will it help to highlight many of the safety principles to which all pilots adhere, it also serves as a guide for the development of training courses that cultivate and refine critical piloting skills.

Instructors and course developers who have not already done so are encouraged to review *Volumes 1 and 2* of this series prior to using the following guide. Both may be accessed on line by visiting http://www.faa.gov/avr/afs/FITS/training.cfm.

System Safety Philosophy

Each aeronautical activity poses its own unique challenges.

When presenting the term "system safety," thoughts immediately turn to algorithms, safety modeling, statistical analysis, etc., subjects that are largely academic and have little to do with practical matters of flight. However, despite this perception, the goal of system safety is quite tangible and easy to quantify. Put simply, system safety looks to reduce the severity and likelihood of risk inherent in all aeronautical activities to lower, acceptable levels. To build upon this further, system safety in aviation involves embracing disciplines such as risk management, aeronautical decision-making, single pilot resource management, and situational awareness, thus reducing risk to the lowest possible levels.

To achieve this end, we must not only understand what it means to be safe, but also the system that provides a framework for our discussion. In aviation, the term "system" is intended to address every element of a flight operation from conception to completion; from the time the flight planning begins to the time you leave the airport after reaching your destination. A system involves the mechanic who maintains your aircraft and the line personnel responsible for refueling operations, as well as the flight service specialist who provides your briefing and the air traffic controller who issues your landing clearance. In short, if it impacts your flight in any perceptible manner, it is part of the system.

Understanding the system, that is the human, environmental, and mechanical aspects of any flight, is the first critical step in identifying hazards. The extent to which we can control these hazards often dictates level of risk. In short, the less control a pilot has over a given hazard, the greater the risk of a critical or even catastrophic event. Such circumstances often demand greater risk control measures to reduce the possibility of an accident. An excellent example of this concept is weather. The elements around us are something over which we have no control, yet we have absolute control over the weather in which we fly. This control is the result of risk mitigating strategies, such as thorough preflight planning and sound judgment.

When training students, imparting this level of awareness represents a formidable challenge. Because not all risk is visible, the system safety methodology must be integral to everything you teach. While a pool of oil under an engine cowl may be an obvious hazard posing immediate risks, others will take experience and keen insight to uncover. As an instructor, your most important goal is to teach these critical thinking skills. Only then can the student apply the aeronautical decision making techniques required to optimize safety. Always remember…

Experience + Analysis = Situational Awareness
Situational Awareness + Aeronautical Decision Making = Risk Management

Hazard versus Risk

The terms “hazard” and “risk” are often used interchangeably, particularly within the aviation community. While both are factors of concern, they are two very unique principles and each must be addressed individually. Although the definitions are covered in section one of this document, each may be illustrated in the context of a true-to-life scenario. For example, a pilot is planning to undertake a flight in instrument meteorological conditions (IMC). The minimum en route altitude along much of the route is 6,000 feet, and the freezing level is reported to be 4,000 feet. The ceiling is 2,000 feet, thus the pilot correctly concludes that airframe and induction icing are very real hazards for this flight.

This all-too-possible scenario highlights a condition that exists in the present, one that could lead to an incident or accident. In short, icing is a classic example of a hazard. The risk posed by this hazard is the aircraft will accumulate a dangerous level of ice, leading to a loss of control. That risk exists only in the future, and requires a triggering event before it poses any danger. In this case, the triggering event could simply be departing in an aircraft not certified for flight in such conditions. Sound judgment and aeronautical decision-making are key mitigation strategies. Another triggering event could be an in-flight failure of the aircraft's deicing system, or an engine failure that necessitates prolonged flight in severe icing conditions. These emergencies would require a far more sophisticated level of planning, yet each must be addressed prior to flight if safety is to be optimized.

This same hazard versus risk model may also be applied to a maneuver required of all certificated pilots, a power on stall. In this example, the hazards are quite evident, and each may be covered succinctly within an instructional exercise. The primary hazard is the possibility of a spin. The risk is that a spin will result in a fatal loss of aircraft control. The possibility of a spin may be completely eliminated by not stalling the aircraft. However, since this maneuver is required as part of the pilot certification process, risk management strategies must be employed. The first risk control measure is an emphasis on coordinated flight during all phases of training. The second is a thorough review of proper stall/spin recovery techniques. Altitude is yet another consideration that can reduce risk. Attention to each element will ensure the requisite degree of safety is maintained.

While the differences between hazards and risks may seem largely academic, the distinctions will become increasingly important as we move further along in our discussions of system safety.

Identifying Hazards

Previously, this document highlighted the importance of understanding the system in which you operate. Absent this consideration, it is impossible to identify hazards, making situational awareness difficult to achieve and sound risk management nearly impossible to exercise. Of course the real challenge involves considering every possible failure involving you the pilot, the aircraft, and the environment in which you operate.

The *PAVE* checklist discussed in *Volume 2* of this series does an excellent job of addressing each of these critical areas. However, because hazards can vary greatly with each unique flight operation, pilots of all experience levels may find themselves at greater risk when first entering "uncharted" territories. For example, the wake created by passing boats poses a unique hazard to the seaplane pilot, something a transitioning land-based aviator may not have considered. The risk of capsizing or damaging float hardware must be mitigated. An instructor would therefore emphasize these and other mission–critical items prior to departure.

One final note regarding hazard identification; because some hazards are present in most every flight, this often leads to a level of complacency that is difficult to overcome. For example, every take-off in a powered aircraft carries with it the possibility of an engine failure. However, pilots of most single-engine aircraft take little time in the moments prior to departure to consider all known risks, along with specific mitigation strategies. When was the last time you performed a pre-departure briefing for an engine failure in your piston single?

Risk Assessment

Once you've identified everything that can go wrong, it is time to carefully consider the consequences of these failings. These consequences, or risks, must then be analyzed with an eye toward determining both likelihood and severity.

Likelihood is arguably the more difficult of the two parameters to quantify and predict. However, the following scale helps to define this measure in the context of our risk equation.

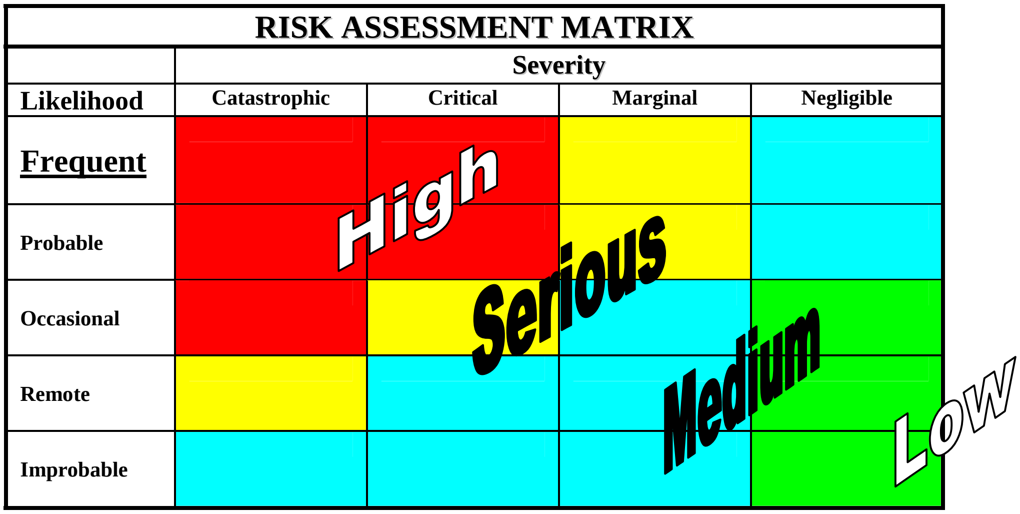
Likelihood Scale Definitions		
Frequent	Individual	Likely to occur often.
	Fleet	Continuously experienced.
Probable	Individual	Will occur several times.
	Fleet	Will occur often.
Occasional	Individual	Likely to occur some time.
	Fleet	Will occur several times.
Remote	Individual	Unlikely to occur, but possible.
	Fleet	Unlikely but can reasonably be expected to occur.
Improbable	Individual	So unlikely, it can be assumed it will not occur.
	Fleet	Unlikely to occur, but possible.

Another term, often used in the insurance industry to describe likelihood, is exposure. Later you will see that as your exposure increases (in terms of frequency), so too does the level of risk.

The second variable in the risk equation is severity, or magnitude of loss. The following scale helps quantify this measure:

Severity Scale Definitions	
Catastrophic	Results in fatalities and/or loss of the system.
Critical	Severe injury and/or major system damage.
Marginal	Minor injury and/or minor system damage.
Negligible	Less than minor injury and/or less than minor system damage.

Use of both the likelihood and severity scales offers a unique insight beyond the normal items covered during the preflight planning process. To some extent, most pilots already undertake a similar thought process, if only informally. However, the true value of this process comes when both measures are reviewed in concert. Only then is the pilot able to make an accurate assessment of the risk involved in any given flight operation. The following chart offers an excellent model for this exercise:



As you can see, frequency and severity combine to help quantify the level of risk. However, it should be noted that risk is often measured on a sliding scale. In other words, the level of risk may vary even when considering the same hazard. Certainly the aforementioned engine-out scenario constitutes a hazard. Still, the risk involved varies greatly depending on a myriad of factors. For example, is the aircraft turbine-powered? If so, the likelihood of a failure (all things being equal) is significantly less than if flying a piston-powered aircraft. Does the aircraft have one or two engines? In the case of the latter, you have doubled the likelihood of an engine failure (exposure increases). However, you may have also limited the potential severity of such an event. Of course if you are not proficient in managing a light piston twin that has suffered an engine failure, the severity portion of the equation will increase dramatically, elevating risk to an unacceptably high level.

In this scenario, both equipment and training are key to assessing the overall level of risk. Each is an element over which a pilot has a superior level of control. Unfortunately this is not always the case. For example, when engines do fail, they tend to do so at their own convenience. In many small aircraft, if an engine failure were to take place at an altitude of 100 feet with 5,000 feet of runway remaining, the risk is considerably less than if that same engine failure occurred at 300 feet above the ground with no remaining runway. This also speaks to the correlation that exists between risk and options. The more options you have, the easier it is to manage risk. However, as with all aviation risks, the better the training, the more options you have available.

Safety Decision Process

The safety decision process ties together previous discussions of hazard and risk. To this point, we have reviewed how best to determine what can go wrong, the potential consequences (risks) involved, and how best to prevent such an occurrence. We have also discussed lessening the possibility of an incident/accident, as well as reducing the severity of a mishap should it occur. The safety decision process takes this a step further by applying judgment and aeronautical decision-making to the formula. Judgment and aeronautical decision-making are then used to determine if the hazards or risks have been addressed to the degree necessary to allow safe flight. Flight instructors will find this a most challenging subject to teach for several reasons.

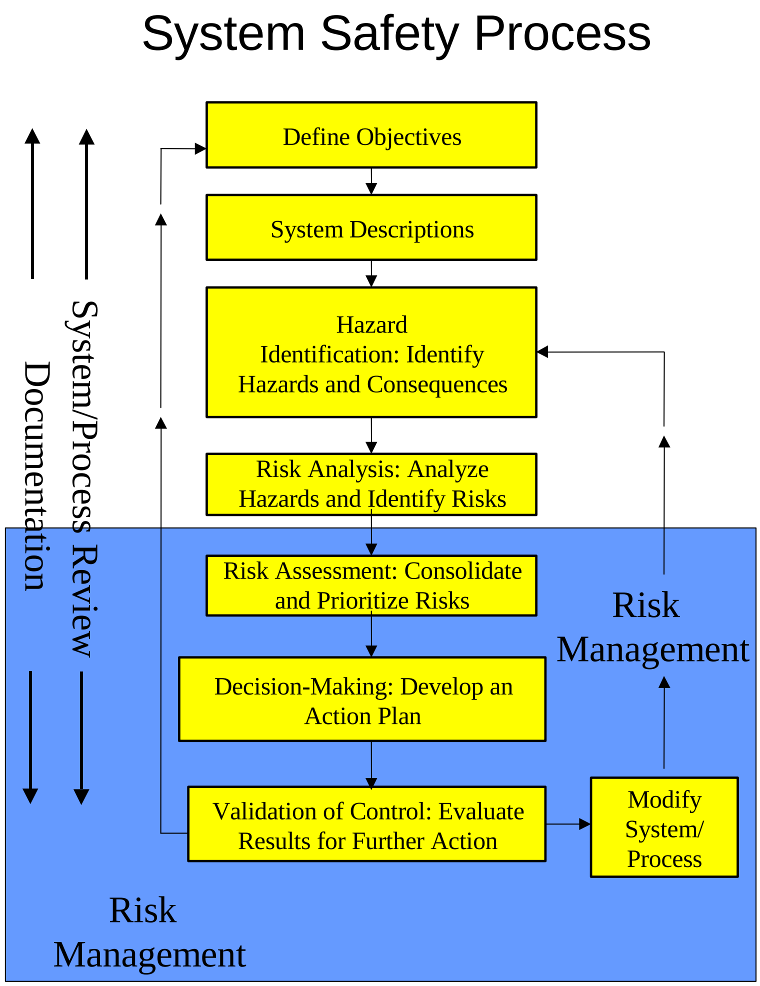
First, pilots tend to be less conservative when predicting likelihood, and more conservative when assessing severity. The difficulty created is that if a pilot determines the likelihood of an event is improbable, it is unlikely he or she will give the proper attention to risk mitigating strategies. Moreover, if severity is always viewed in the extreme, this could lead to resignation on the part of the aviator. Ideally, a pilot would begin by viewing all potential events as probable, and then plan mitigation strategies that reduce any potential effects (severity) to a negligible level. Once that exercise is completed, attention may then be given to reducing the probability of an occurrence.

When attempting to teach judgment and aeronautical decision-making, there are two other critical forces conspiring against you; perception and risk aversion. While it is best to look at these as opposite sides of the same coin, each carries with it unique challenges. Learning to identify the traits that accompany each may be helpful in preparing your client to face the challenges of operating safely in the modern airspace system.

Let us begin with a look at perception. Perception is focused largely on the hazard side of the "coin." For example, one pilot may perceive level-2 storm activity as a hazard. A second pilot may look upon it as simply another factor to be considered, no more or less significant than weight and balance calculations or runway length. An effective way to determine if perceptive differences will be an issue is to discuss a series of typical flight scenarios with your client. What factors does he or she consider most important when planning and conducting a particular flight? Understanding an individual's operational philosophy can be most helpful in determining when and where potential problems can occur.

On the other hand, the dynamics completely change when risk aversion enters the equation. In this case, a pilot may perceive a hazard exists, but where one pilot may be willing (for a myriad of reasons) to accept the associated risks, a second pilot simply will not. As a practical matter, the dissonance brought on by risk aversion is the most difficult to resolve. While it is possible to modify perceptions based on rational discussion, risk aversion tends to be more central to a person's psychological construct. As a result, it is nearly impossible to change. Thankfully, these issues are also the easiest to identify. Diagnosing these two critical traits and addressing them in your training activities is one of the most valuable services you can provide your client.

Another difficulty lies in the fact that not everyone views hazards or risks in the same manner. Let's use an obvious example to illustrate this point. A 17-knot crosswind is a hazard in that it poses an element of risk. On the other hand, the degree of risk varies with a multitude of factors, such as pilot experience, aircraft type, etc. A seasoned aviator, flying a familiar aircraft, may not perceive a great risk. On the other hand, a student pilot flying a Cessna 152 is likely to consider this a very risky undertaking; same condition, two different responses. Who is correct? Realistically, both may be. Each pilot has exercised aeronautical decision-making and risk management. The more experienced pilot has decided to conduct the flight because it is within his or her ability to do so safely. The risk can be mitigated through a careful review of weather, the planning of an alternate, etc. The student, on the other hand, chose to eliminate the hazard (and along with it, risk) completely by staying on the ground.



The flow chart above illustrates the previously outlined processes. Because many of the hazards associated with general aviation activities are so well known, they may almost be taught as rote subject matter. Accurately assessing the level of risk requires greater skill, because judgment now enters the equation. The pilot must determine what control measures can be used to manage risk. The final goal, the one offering the greatest challenge, is developing the aeronautical decision-making skills needed to determine if and how to safely go forward with a flight.

For clients who ask you to provide a sound litmus test, consider offering these questions and discussion points. "Do you have the ability to safely complete this flight if everything were to go right?" If yes, then move on to ask "Do you have the ability to safely complete this flight if everything were to go wrong?" If the answer is no, ask them to identify those things that could fail, and outline how (or if) the likelihood or severity can be reduced. If your student is unable to keep all elements of the flight within the low-medium range of the risk assessment matrix, perhaps it's best to stay grounded that day, or consider an alternative to the proposed flight.

Obstacles and Constraints

By now it is probably clear the techniques and practices being presented mirror those of other aviation communities. Airline, corporate, and military training organizations have all integrated similar measures into their instructional programs. In all cases, the results have been overwhelmingly positive. But how will this all work in the world of GA?

Consider that general aviation is far more diverse than any other segment of the civil aviation family. By its very nature, the GA regulatory structure and operating environment differs greatly from that which defines the air carrier and corporate aviation communities. These operators enjoy considerable advantages that contribute to their higher level of safety, some of which include:

1. Intensive, type-specific training
2. Mandated and highly structured recurrent training
3. Highly experienced instructors
4. Emphasis on scenario-based versus "stick and rudder" training
5. The use of sophisticated, level-qualified flight simulators in training
6. Greater experience (total hours, time in type, recency)
7. Crew-served versus single-pilot cockpits
8. Majority of operations into towered versus non-towered airports
9. IFR versus VFR, and with it increased use of air traffic services
10. Improved availability of weather data (both preflight and en route)
11. Flight level versus low altitude flying
12. More stringent regulatory oversight
13. Higher overall level of standardization
14. Operation of newer aircraft
15. Multi-engine versus single-engine
16. Turbine versus piston power
17. Aircraft technology including ground proximity warning systems, traffic alert/collision avoidance systems, integrated flight management systems, etc.

A review of these 17 items leads to the conclusion that training figures prominently in many of the safety advantages enjoyed by airlines and corporate operators. It is also the one component without which most of the others would have little value. For example, it is difficult to leverage the full advantages of cockpit resources (technical or otherwise) without the proper training.

Training is also critical in helping to close the gap in other areas of safety. For example, while it may not be practical (or even possible) for a GA pilot to operate in the flight level environment, increased skill in risk management and aeronautical decision-making will allow the pilot to fly more safely at lower altitudes, where factors such as weather, terrain, route selection, etc. play a greater role. Again we find ourselves emphasizing the tenets of system safety. The virtue of this methodology is that it not only addresses the training needs of the current GA community, it also prepares pilots to effectively fly and manage the next generation of technically advanced aircraft. Moreover, this focus will be crucial in training the emerging population of sport pilots, whose operational missions may look very different from those of the "traditional" GA pilot.

Training Methodology

When introducing system safety to flight instructors, the discussion invariably turns to the loss of traditional stick and rudder skills. The fear is that emphasis on items such as risk management, aeronautical decision-making, single pilot resource management, and situational awareness will detract from the training so necessary in developing safe pilots. Also, because the FAA's current practical test standards place so much emphasis on stick and rudder performance, there is concern that a shifting focus would leave their students unprepared for that all-too-important check ride.

System safety envisions flight training that occurs in three phases. First, there are the traditional stick and rudder maneuvers taught today. In order to apply the critical thinking skills that are to follow, pilots must first have a high degree of confidence in their ability to fly the aircraft. Next, the tenets of system safety will be introduced into the training environment. In the manner outlined previously, students will begin to learn how best to identify hazards, manage risk, and use all available resources to make each flight as safe as possible. This will be accomplished through scenarios that emphasize the skills sets being taught. Finally, the student will be introduced to more complex scenarios demanding focus on several safety-of-flight issues. To illustrate this three-phased approach, let's review a previous lesson utilizing a system safety approach.

In *Volume 1* of this series, you were introduced to the system safety methodology using a traditional stick and rudder maneuver, short field landings. As an instructor, your initial focus is on developing the stick and rudder skills required to execute this operation safely. These include power and airspeed management, aircraft configuration, placement in the pattern, wind correction, determining the proper aim point and sight picture, etc. By emphasizing these points through repetition and practice, the student will eventually acquire the skills needed to execute a short field landing. These tools are necessary in training a competent pilot, thus the FAA's rationale for testing proficiency in this operation during a practical test. As an instructor, if you taught nothing more about short field landings than the points cited above (which we'll call phase I), you will have prepared your student to "pass" this element of the practical test. However, ask yourself if you have prepared him for the real-world challenges he may face once he's left the training environment.

As part of phase II, it is vital that students be introduced to the many factors that come into play when performing a given flight maneuver. In the case of a short field landing, many of those factors, including runway conditions, no-flap landings, airport obstructions, and rejected landings are spelled out in *Volume 1* of this series. This example also illustrates how the introduction of such items need not increase training times. In fact, all of the hazards or considerations referenced in the short field landing lesson plan may be discussed in detail during the ground portion of your instructional program. For example, you have discussed how such a training exercise will be conducted at your local airport, which enjoys an obstruction-free 6,000-foot runway. In the course of your lesson, ask your client to consider the implications of operating the same aircraft out of a 1,800-foot strip, with an obstruction off the departure end. Add to that additional considerations, such as operating the aircraft at close to its maximum gross weight under conditions of high density altitude, and now you have taken a single training scenario and added several layers of complexity. The ensuing discussion will prove a valuable training exercise, and it will come with little additional ground and no added flight training.

Finally, phase III takes the previously discussed hazards, risks, and considerations, and scripts them into a complex scenario. This forces the student to consider not only a specific lesson item (in this case short field landings), but also requires that it be viewed in the greater context of the overall flight. For example, on a cross-country training flight, the student is presented with a realistic distraction, perhaps the illness of a passenger. This forces a diversion to an alternate for which the student has not planned. The new destination airport has two runways, the longest of which is closed due to construction. The remaining runway is short, but while less-than-ideal, should prove suitable for landing. However, upon entering the pattern, the student finds the electrically driven flaps will not extend. The student must now consider whether to press on and attempt the landing, or proceed to a secondary alternate.

Every flight offers its own unique training opportunities.

If he decides to go forward and attempt the landing, this will prove an excellent time to test the requisite stick and rudder skills. If the student decides to proceed to a second alternate, this opens a host of new training opportunities. You may allow him to proceed, which will further test cross-country skills, such as navigation, communication, management of a passenger in distress, as well as the other tasks associated with simply flying the aircraft. If you decide to add a new twist, introduce a partial engine failure as he begins the diversion. Now, will the student decide to continue to an alternate with an ailing power plant? Will he attempt to land on the open, albeit shorter runway or will he attempt to make an emergency landing on the longer, closed runway? Is that longer runway obstruction free? Would landing there afford a greater chance of emerging unscathed?

While inappropriate for a student undertaking his or her first cross-country training flight, this scenario offers many training opportunities that test both mechanical skills as well as risk management. Moreover, much like phase II, this comes with no additional training requirements. You're already teaching your students cross-country operations, which include emergency diversions to an alternate airport. You are also required to teach short field and no-flap landings. Of course simulated engine out emergencies are something emphasized in all phases of flight training. The outlined methodology simply takes a series of seemingly unrelated tasks, and scripts them into a training exercise requiring both mechanical and cognitive skills to successfully complete.

In addition, system safety may be applied to important safety lessons with less quantifiable performance standards. For example, controlled flight into terrain, or CFIT, is an issue of concern to all pilots. In general aviation, CFIT normally results from a combination of factors including weather, unfamiliar environment, non-standard procedures, breakdown or loss of communications, loss of situational awareness, and lack of sound risk management techniques. Collectively, these conditions are difficult to replicate in most flight-training environments. However, the subject may still be covered effectively during ground school and cross-country flight operations by using system safety methodology. Because CFIT is always the final "link" in the accident chain, it must be taught within the context of other flight operations; operations that increase the likelihood of a CFIT accident. This will not only help illustrate how easily these accidents can occur, it also highlights the conditions under which such accidents most often take place.

Weather is always a consideration when planning your flight.

Similarly, other critical operational issues, such as weather and runway safety, all lend themselves to system safety training. The section that follows will highlight strategies for introducing these important concepts to your clients.

Developing Training Scenarios

Similar to FITS, system safety uses a scenario-based approach to impart knowledge during flight training. This methodology, as time tested as any used throughout civil or military aviation, is advantageous for several reasons. First, it acknowledges that while experience is the best teacher, it is often difficult to acquire in sufficient quantity during the prescribed training regimen. Because experience is a key variable in the risk management equation, instructors must devise ways to infuse numerous lessons within a relatively short period of training. Scenario-based training allows you to do this more efficiently.

Next, the consistent use of system safety principles within the context of realistic training scenarios helps to cultivate critical thinking skills.

Finally, the use of scenario-based training adds a level of fun and excitement to aviation training that is difficult to achieve solely through repetitive practice. This helps keep students engaged and interested, and also illustrates the value of their training beyond preparing for a FAA practical test.

Using the CFIT example provided above, let's take a look at a lesson plan and training scenario using system safety methodology.

Lesson Plan (Example 1)

1. Type of training: **Recurrent/proficiency**

2. Maneuver or training objectives: **Introduce student to CFIT hazards and risk management strategies during a cross-country flight.**

3. Possible hazards or considerations (These examples are provided for training purposes only. Items may be added or omitted as necessary to reflect your unique operation):

- **a. Airport lighting**
- **b. Pilot familiarity with airport**
- **c. Surrounding terrain and topography**
- **d. Precipitous terrain**
- **e. Available approaches**
- **f. Published departure/arrival procedures**
- **g. Availability of alternates**
- **h. Air traffic radar/communications coverage**
- **i. Differences in pilot/controller language**
- **j. Availability of terrain/ground proximity warning systems**
- **k. Availability of a primary flight display (PFD) or moving map GPS**
- **l. Availability of an autopilot system**
- **m. Pilot familiarity with aircraft/on-board equipment**
- **n. Single pilot versus crew operations**
- **o. Pilot/crew recent experience**
- **p. Flight physiology/psychology**
- **q. Length of flight**
- **r. Day versus night**

s. Visual versus instrument meteorological conditions
t. Density altitude

4. Mitigation strategies and resources (Every hazard or consideration should be addressed through the use of some mitigating strategy or resource. Those provided below serve only as an example to illustrate the system safety methodology.):

Airport lighting: The availability of a complete/operational approach lighting system may serve as a significant mitigating factor in reducing the risk of a CFIT accident. Based on experience and a careful review of the airport/facility directory (A/FD), the pilot in command should determine the adequacy of the approach lighting system prior to departure. If the system is inadequate, and the consequences of using the airport are determined to be unacceptable, an alternative (see item 5 of this lesson) must be considered.

Also, the pilot in command must anticipate the possibility of an airport lighting system failure while attempting to land, particularly if a lighting system is a factor in mitigating other risks. The probability of such an occurrence may increase when flying into a non-tower controlled facility. This event should be anticipated during the preflight planning process, and an alternate plan of action developed. Notices to Airmen (NOTAMs) should also be reviewed to help identify any existing difficulties prior to launch.

Pilot familiarity with airport: While experience flying in to or out of a given airport offers no guarantee of increased safety, it very often does help to reduce pilot workload. Familiarity with air traffic and approach procedures, terrain, etc. all help to reduce the potential for confusion, allowing the pilot to perform more critical cockpit tasks.

While it is difficult to quantify the CFIT risk presented by flying into an unfamiliar airport, such considerations are often used as risk control measures to counter other safety issues presented in this lesson. During the preflight planning process, the pilot should review all available materials referencing the intended airport of arrival. This preparation will pay dividends should other unanticipated risks materialize during the flight.

Surrounding terrain and topography: CFIT accidents are often associated with mountainous terrain. However, there are many other potential hazards of which a pilot should be aware. For example, the pilot should know if the airport is surrounded by buildings, cell phone towers, or transmission lines that create potential risks. Sectional/terminal charts, the A/FD, approach plates, and NOTAMs may prove useful in making this determination. Because striking any object in flight rates as severe or catastrophic on the risk assessment scale, the only way to effectively manage risk is by reducing the probability of an occurrence. In this case, knowledge and thorough planning are the best tools.

Another potentially significant topographical hazard is the "black-hole" night-time approach. Unless the pilot is familiar with the destination airport, this hazard may not be known prior to arrival. There are, however, clues that may foreshadow the possibility of such conditions. For example, if flying into a small airport located outside a major metropolitan area or population center, the pilot should be aware that a black hole approach is more likely. If an airport is located on an island, this too may create difficulties. Also, a lack of ambient (moon) light may contribute greatly to the black hole phenomenon.

In any case, a pilot flying into an unfamiliar airport at night should review chapter 15 of the *Pilot's Handbook of Aeronautical Knowledge* as part of his or her planning process. Finally, should a pilot find himself succumbing to the effects of this illusion, good judgment should be demonstrated by immediately terminating the approach. If able, another runway could be used, or the pilot may elect to proceed to an alternate airport. Using the risk assessment chart; this scenario would, at best, rate as critical on the severity scale. If any additional problems are encountered, this immediately constitutes a serious (quickly approaching high) risk operation.

Precipitous terrain: This is one of the most obvious hazards contributing to CFIT accidents. Accidents such as the one involving a Gulfstream III attempting a night instrument approach into Aspen, Colorado are tragic reminders of just how dangerous flying can be. Again, because the severity of CFIT accidents due to precipitous terrain always occupies the high end of our risk assessment scale, the only way to reduce the risk is to lower the probability of an occurrence. This may be done by first familiarizing the student with all available airport and topographical information prior to the flight. If there are lingering concerns, consider one of the alternatives listed in item 5 of this lesson plan.

Available approaches: While all published approach procedures are designed to ensure adequate terrain clearance, some present greater challenges than others. For example, most pilots would prefer the precision guidance offered by an instrument landing system (ILS) approach when arriving at an unfamiliar airport, at night, under instrument meteorological conditions. In fact, weather conditions may demand the lower minima facilitated by such an approach. In any case, if the flight requires the conduct of an instrument approach procedure, selecting the best one may help in reducing workload, along with possible risks.

Approach construction is also a consideration when assessing risk. For example, does the procedure have an atypically shallow/steep approach angle? Does the procedure contain several intermediate step-downs? Is the approach aligned with the runway, or does it require a circling maneuver? While approach availability may only be viewed as a risk control measure when discussing other hazards, approach construction may, in fact, be considered a hazard necessitating it own unique mitigating strategies. Carefully reviewing approach plates prior to departure may stave off potential difficulties. Under some circumstances, the pilot may elect to execute another procedure, fly to an alternate airport, or wait for visual conditions to prevail.

Published departure/arrival procedures: The main advantage offered by a published departure or arrival procedure is that of predictability. Because a published procedure allows a pilot to more precisely anticipate his or her route of flight, situational awareness is increased. This is particularly valuable (and perhaps critical) during high-workload phases of flight, such as when operating in a terminal environment. Again, while the presence or absence of a published arrival/departure procedure might not factor into a pilot's list of hazards, it may be considered a risk control measure when viewed along side other workload issues. However, the only way to realize a benefit in this case is to carefully review these procedures as part of the preflight preparation.

Availability of alternates: Depending on the rules under which a pilot operates, the type and availability of alternates may be governed by part 91 regulatory requirements. However, in most cases, both IFR and VFR pilots have at least some latitude in selecting alternate airports. When operating IFR, it is important not only to understand the legal requirements for selecting an alternate, but also the availability and types of approaches. Certainly no pilot would want to select an alternate that increases the opportunity for a CFIT accident. Accordingly, if the only alternate available is an airport surrounded by high terrain, and weather dictates that a diversion is possible, a pilot may want to consider planning his or her flight to a different airport (if practical) or simply waiting until conditions improve.

When quantifying the implications of an alternate during preflight planning, consider availability to be a risk control measure, while the absence of an alternate airport may be a hazard, depending on other conditions (weather, approach type, etc.).

Air traffic radar/communications coverage: When evaluating the role air traffic radar and communications coverage will play in a proposed flight, the pilot is likely to view it in a manner similar to quality alternate airports. Having radar and communications coverage to the surface certainly helps in mitigating other risks, however, the absence of one or both of these services may constitute a new set of hazards, and with them serious risks. This may be particularly true when viewed in conjunction with other operational factors. If flying into an area that may not have adequate radar or communications coverage, pay special attention to minimum en route and obstacle clearance altitudes, as well as published missed approach procedures.

Differences in pilot/controller language: Because most GA pilots in this country will confine their flight operations to English-speaking countries, this factor may never become a consideration. However, if planning a flight south of the border, or flying with another pilot for whom English is a second language, take time to consider the potential implications. Pay particular attention to factors such as obstacle clearance and minimum safe altitudes if being vectored by a controller whose native language is other than English. A misunderstood vector or altitude assignment can, and has, led to catastrophic results.

Availability of terrain/ground proximity warning systems: While generally thought of as technology reserved for high-end aircraft, an increasing number of GA cockpits are now home to advanced avionics. If a pilot has never flown with such systems, this will likely not factor into the planning equation. If the aircraft is equipped with a terrain warning system, the key in determining its value as a risk control measure is the pilot's knowledge and proficiency in its use. As with many cockpit technologies, pilots are often better served by not having a piece of equipment, as opposed to having equipment they are unable to use effectively. The best strategy in making this a risk control measure is to familiarize oneself with all aircraft systems prior to departure.

Availability of a primary flight display (PFD) or moving map GPS: Modern cockpits equipped with PFDs and moving map GPS units offer a greater level of situational awareness than was ever before possible. The difficulty often lies in how best to manage the flight if such systems were to fail. Again, if this is not a situation for which a pilot is prepared, an otherwise minor difficulty could quickly escalate into an emergency situation. When training pilots in the use of these systems, instructors and students should have candid discussions concerning the implications of failures involving the GPS or PFD and how best to treat and manage problems such as increased workload, availability of alternates, etc.

Availability of an autopilot system: In a single-pilot environment, an autopilot system can greatly reduce workload. As a result, the pilot is free to focus his or her attention on other cockpit duties. This cannot help but to improve situational awareness and reduce the possibility of a CFIT accident. While the addition of an autopilot may certainly be considered a risk control measure, the real challenge comes in determining the impact of an inoperative unit. If the autopilot is known to be inoperative prior to departure, this may factor into the evaluation other risks. For example, the pilot may anticipate an NDB approach down to minimums on a dark stormy night, into an unfamiliar airport surrounded on 3 sides by mountains. In such a case, the pilot may have been relying heavily on a functioning autopilot capable of flying a coupled approach. This would free the lone pilot to monitor aircraft performance. In this case, an ailing autopilot could be the single factor that takes this from a medium to a serious risk. At this point, an alternative needs to be considered.

On the other hand, if the autopilot were to fail at a critical (high workload) portion of this same flight, the pilot must be prepared to take action. Instead of simply being an inconvenience, this could quickly turn into an emergency if not properly handled. The best way to ensure a pilot are prepared for such an event is to carefully study the issue prior to departure and determine well in advance how an autopilot failure is to be handled.

Pilot familiarity with aircraft/on-board equipment: As previously discussed, pilot familiarity with all equipment is critical in optimizing both safety and efficiency. If a pilot is unfamiliar with any aircraft systems, this will add to workload and may contribute to a loss of situational awareness. So critical is this level of proficiency that it should be looked upon as a requirement, not unlike carrying an adequate supply of fuel. As a result, pilots should not be inclined to look upon this as a risk control measure, but instead as a hazard with high risk potential if they are *not* extremely familiar with the aircraft and its systems.

Single pilot versus crew operations: The addition of a second crewmember can be an extremely valuable risk control measure when evaluating CFIT potential. A well-managed crew facilitates reduced workloads. It also allows the pilot not flying to monitor pilot and aircraft performance at critical phases of flight. Both of these factors help reduce the risk of CFIT accidents. However, to achieve maximum benefit, crew resource management is extremely important. Pilots should discuss how cockpit duties would be divided during the flight, and the pilot in command determined prior to departure.

Pilot/crew recent experience: Recency of experience requirements are outlined in the *Code of Federal Regulations*, however, these are only minimal guidelines. This consideration illustrates the axiom that regulatory compliance does not equal safety. Recent experience speaks to both proficiency and comfort level. If the pilot has a great deal of recent flying experience, particularly in conditions similar to those anticipated during the flight, this is a valuable risk-mitigating factor. If the pilot has some “rust” that needs to be loosened, a night circling approach to minimums in mountainous terrain might not be the time to do it. In such cases, an alternate should most certainly be considered.

Flight physiology/psychology: A clear mind and rested body are two of the most important resources available to a pilot. When one or both of these is compromised, risk levels quickly elevate. As the complexity of the flight increases, distractions, fatigue, or other physiological difficulties compound risk exponentially, and may quickly turn a medium risk flight into a high-risk operation. Unfortunately, these same issues often impair judgment. As a result, responsible aeronautical decision-making may be compromised. These factors should be discussed at length with students during every phase of training, not simply when reviewing CFIT potential.

Length of flight: Length of flight is closely tied to the item above in that it often introduces issues of fatigue. As a result, the dreaded “get-home-itis” begins to become a factor. The best strategy here is simply to break long flights into shorter, more manageable legs, even if it means pushing back the proposed time of arrival. This allows the pilot to be well rested and engaged if and when called upon to execute that night circling approach.

Day versus night: When discussing CFIT potential, day versus night operations are a major consideration. The darkness of night obscures guy wires, unlit towers, hilltops, trees, etc. When coupled with the fatigue factor that often accompanies night operations, the chances of a CFIT accident can increase. This risk can be managed by carefully reviewing charts, NOTAMs, and A/FDs prior to departure. If a particular approach or airport environment presents a difficult challenge, instead of flying at night, the pilot may want to consider an alternative from item 5 of this lesson plan.

Visual versus instrument meteorological conditions: Because instrument conditions are the most significant contributor to CFIT accidents, they demand an aggressive application of risk control measures. In a challenging operational environment, IMC can turn a medium risk into a high-risk flight. When added to factors such as precipitous terrain or night operations, the potential for a CFIT accident increases exponentially. To mitigate this risk, the pilot must not only be prepared for any normal occurrence, but any emergencies that might arise. Pilots should consider the value of autopilot or GPS moving map systems when undertaking such a flight. If that's not an option, perhaps a second pilot, or an alternative airport are options worth reviewing.

Density altitude: More often than not a contributing factor in CFIT accidents under VFR conditions, density altitude is a major consideration during summer months or in areas of high elevation. Many a pilot has flown into a canyon, only to find escape impossible due to poor aircraft performance. These same conditions can also create problems when taking off or going around following an attempted landing. The aircraft may fail to climb as anticipated, so instead of clearing the obstacle, the pilot becomes another CFIT statistic. When operating in a high density altitude environment, make certain to review aircraft performance figures, and add a generous margin for safety. If operating into an airport surrounded by obstructions or high terrain, be certain to factor such conditions into the risk assessment.

5. <u>Alternatives</u>:

Time: When planning a training exercise, time is always a variable to consider. For example, the pilot and/or instructor may determine that based on forecast weather conditions, it would be prudent to delay a training exercise (or other mission) until the winds, ceiling, or visibility improve.

Location: If airport conditions do not allow the planned training or operational exercise to be conducted safely, another venue should be chosen. This flexibility should be stressed during the planning/instructional process.

Abort training exercise: This alternate is included to emphasize there are times when aborting a flight or choosing not to perform a particular maneuver or operation is an appropriate and prudent course of action.

6. Requisite skill sets: **Proficiency in cross-country flight planning and operations, as well as skill in managing the aircraft and its systems.**

7. Scenario-based training methodology: **The instructor will integrate two or more of the identified hazards into a cross-country flight operation. The choice of hazards will be made so as to realistically highlight risks likely encountered under similar circumstances. This will force the student to use both mechanical and cognitive skills in a dynamic environment- one that contains the distractions, challenges, and potential hazards found in a typical GA mission.**

8. Training materials: **Aircraft pilots operating handbook/ flight operations manual (POH/FOM, AF/D), sectional/terminal area charts, approach plates, NOTAMs, *Pilot's Handbook of Aeronautical Knowledge*, and any other necessary flight planning tools.**

Clearly, CFIT is a complex issue with many operational considerations. This lesson plan highlights many of the CFIT hazards that could materialize on any given flight. To illustrate the importance of addressing these issues during the preflight planning process, review this lesson with your student as part of their cross-country training. Determine which hazards are applicable and how best to manage them. Ground school lessons may also incorporate accident/incident scenarios using data from the National Transportation Safety Board (http://www.ntsb.gov/ntsb/query.asp), the FAA (http://www.faa.gov/avr/aai/iirform.htm), and the National Aeronautics and Space Administration's Aviation Safety Reporting System (http://asrs.arc.nasa.gov/) websites. The flight portion could use the same resources. For example, to illustrate the dangers of high density altitude, the instructor could limit engine power and simulate high terrain on all sides of the aircraft. This may force the pilot to choose between a CFIT or possible stall/spin accident, and a forced landing into an off-airport location.

This lesson plan also allows an instructor to clearly illustrate how the cumulative effects of several hazards may add up to an unacceptable risk. For example, while a pilot may be prepared to shoot an instrument approach down to minimums, he or she may not be prepared to shoot a circling NDB approach down to minimums, at night, in mountainous terrain, single pilot, with an inoperative autopilot system after flying six hours. In such cases, sound judgment and aeronautical decision-making are the most valuable risk control measures available.

Of course CFIT isn't only potential danger pilots may encounter. Statistically, weather often poses some of the greatest risks to general aviation pilots, regardless of their experience level. As with CFIT, system safety gives pilots the tools they need to avoid hazardous weather. Using the *FITS Personal and Weather Risk Assessment Guide* (available at http://www.faa.gov/avr/afs/FITS/Pub_safety.cfm), let's briefly review a lesson plan covering weather. While the factors involved in making an informed go/no-go decision are numerous and varied, a few are highlighted here to demonstrate the system safety approach.

Lesson Plan (Example 2)

1. Type of training: **Recurrent/initial**

2. Maneuver or training objectives: **Familiarize student with the tools needed to develop their personal weather minimums.**

3. Possible hazards or considerations (These examples are provided for training purposes only. Items may be added or omitted as necessary to reflect your own unique operation):

   a. **Time in aircraft (total)**
   b. **Recent experience (total and in aircraft type)**
   c. **Aircraft equipment**
   d. **Instrument versus non-instrument rated**
   e. **VFR versus IFR operation**
   f. **Day versus night**
   g. **Purpose of flight**
   h. **In-flight weather resources**

4. Mitigation strategies and resources (Every hazard or consideration should be addressed through the use of some mitigating strategy or resource. Those provided below serve only as an example to illustrate the system safety methodology.):

Time in aircraft (total): When undertaking any flight, particularly in challenging weather, aircraft familiarity may prove a significant risk control measure. This familiarity will typically come with time in type, and as a result, pilots who have more time in a given aircraft may be comfortable flying in conditions they might otherwise avoid. Conversely, even an experienced instrument pilot may be reluctant to fly an aircraft into difficult instrument conditions without first logging a few additional approaches. In this case, time in type (or lack thereof) may actually be a hazard that compounds other risk factors. To mitigate this risk, pilots must train to their own standards of comfort and proficiency before flying in marginal conditions. If unable to get the needed training in a timely manner, select an alternative from item 5 of this lesson plan.

Recent experience (total and in aircraft type): Similar to the previous item, recent total and in-type experience can help mitigate other potential risks. For example, a pilot may have less total time in one aircraft when compared to another. However, during the last six months, he or she has flown exclusively in the former. In such a case, the pilot could very well have a greater level of comfort (and proficiency) with the aircraft in which he or she has less total flying time. A good rule of thumb when assessing risk is this; if it becomes necessary to give more than a passing thought to aircraft familiarity as part of the preflight risk assessment, this operation may already occupy the medium tier of the risk assessment matrix. Add to that other hazards or considerations, and the risk could quickly elevate to unacceptable levels. If this is the case, consider an alternative to reduce or eliminate risk, such as bringing along a more experienced instructor or pilot.

Aircraft equipment: Aircraft equipment is an excellent example of a risk control measure. For example, an autopilot can reduce workload, as could a moving map or primary flight display. De-icing and/or anti-icing equipment may also prove a significant risk control measure. However, when relying on a specific piece of equipment to maintain safety of flight (such as a de-icing system), the pilot must also consider the risks associated with a failure of that system. In each case, an alternate plan of action must be developed to mitigate any potential dangers. Again, if the risk cannot be reduced to acceptable levels, look to the hazard-reducing alternatives listed in item 5 of this lesson.

Instrument versus non-instrument rated: An instrument rating is an extremely valuable tool for increasing the utility of your pilot certificate. However, because an instrument rating allows pilots to operate in conditions that would have otherwise been avoided, it also potentially adds a host of new considerations to the flight planning exercises. For example, the full benefit of an instrument rating cannot be realized unless the pilot is both legally current and proficient enough to operate safely under instrument meteorological conditions. Superior judgment and aeronautical decision-making are needed to make this critical safety assessment.

It should also be noted that while an instrument rating can be an important risk control measure when operating in marginal VFR conditions, a non-instrument rated pilot could operate with the same degree of safety utilizing the proper risk management strategies. For the VFR pilot, there are two essential questions that must be answered. First, is there a 100% chance that no instrument meteorological conditions will be encountered during this flight? If so, this is one hazard that need not be considered. If not, ask the second question. If the chances of completing this flight under VFR conditions are less than 100%, are there manageable options that will allow a safe diversion to an alternate destination? If so, develop an appropriate plan of action as part of the preflight planning efforts. If not, the only responsible alternative may be to wait for improved weather.

VFR versus IFR operations: Both VFR and IFR operations carry their own unique challenges regarding weather, especially when it comes to making a competent go/no-go decision. If a pilot is restricted to VFR flight and instrument conditions prevail, the issues involved are quite clear. However, if the weather is clear and sunny, but marginal or instrument conditions are forecast, preflight planning should focus heavily on identifying and evaluating all available options.

If an alternate plan is feasible, and the pilot elects to undertake the flight, he or she will do so well prepared to meet the challenge. If the options available are not to the pilot's liking, an alternative from item 5 of this lesson plan may be the best course of action.

On the other hand, if a pilot is instrument rated and both legal and comfortable to fly in instrument condition, he or she must assess the risks involved just as would be done on any flight. If an approach to minimums is anticipated, the pilot will make certain to familiarize himself with the approach procedures for any alternate airport(s). If applicable, the pilot will identify any areas of VMC in case of an electrical or communications failure. If marginal VFR conditions prevail, an instrument flight plan should be filed. This will help provide an easy "out" should conditions deteriorate to below VFR minimums.

Day versus night operation: While not a meteorological condition, the onset of darkness may factor significantly into the hazard equation, particularly where weather is concerned. For example, if called upon to shoot a circling approach to minimums, most pilots would much prefer to conduct such a maneuver during daylight hours when the risk of CFIT is reduced. Also, unless the aircraft offers the benefit of on-board radar or a data-link weather system, visual contact may be the only sure method of avoiding convective activity. For planning purposes, personal minimums should be adjusted to reflect the added difficulties of night flying.

Purpose of flight: Depending on the circumstances under which a flight is conducted, the pilot may feel compelled to assume certain risks that might otherwise be avoided. For example, if a commitment has been made to attend a business meeting with an important client, the motivation to fly is far greater than if simply taking a pleasure flight to enjoy a Sunday morning brunch.

If a pilot flies regularly for business purposes, the best way for him or her to avoid taking unnecessary risks is by never getting backed into a corner by planning a flight that must be completed. Also, pilots must develop a set of personal minimums to which they will adhere regardless of the flight's importance. This should be done at a time when there are no competing pressures (or agendas) that may exert undue influence. This is a factor over which a pilot has absolute control, so instructors should emphasis that point with their students.

In-flight weather resources: Knowing what resources are available and how best to use them is vital in developing practical risk control measures. Resources such as automated terminal information systems (ATIS), automated weather observation systems (AWOS), hazardous in flight weather advisory services (HIWAS), as well as Flight Watch and other air traffic services can figure prominently in managing a safe flight. To make the most of these systems, pilots should not only use aeronautical charting information to determine the availability of these resources, but also the limitations and benefits of each. This will not only help in determining options at the preflight stage of planning, it will also allow the pilot to tactically manage any in-flight weather hazards before they turn into serious risks.

5. Alternatives:

Time: When planning a training exercise, time is always a variable to consider. For example, the pilot and/or instructor may determine that based on forecast weather conditions, it would be prudent to delay a training exercise (or other mission) until the winds, ceiling, or visibility improve.

Location: If airport conditions do not allow the planned training or operational exercise to be conducted safely, another venue should be chosen. This flexibility should be stressed during the planning/instructional process.

Abort training exercise: This alternate is included to emphasize there are times when aborting a flight or choosing not to perform a particular maneuver or operation is an appropriate and prudent course of action.

6. Requisite skill sets: **Knowledge of basic weather theory, cross-country flight planning and operations; as well as skill in managing the aircraft and its systems.**

7. Scenario-based training methodology: **The instructor will integrate two or more of the identified hazards into a cross-country flight operation. The choice of hazards will be made so as to realistically highlight risks likely encountered under similar circumstances. This will force the student to use both mechanical and cognitive skills in a dynamic environment- one that contains the distractions, challenges, and potential hazards found in a typical GA mission.**

8. Training materials: **Aircraft POH/FOM, *Advisory Circular (AC) 00-45, AC 00-6*, and any other necessary flight planning tools.**

Like CFIT, weather is not a subject that can be discussed in a vacuum. For example, you cannot assume because the visibility and ceiling are higher for a given geographical area that the flight has a lower level of risk. You may in fact incur less risk flying into conditions reported as 200 and ½ than would be encountered in an area reporting 400 and ¾. Perhaps the airport with lower weather offers a precision approach, radar services to the surface, flat surrounding terrain, and several near-by alternates. On the other hand, the airport with better weather may only be serviced by a non-precision procedure and have no radar services. There may also be convective activity in the area; where as the other airport had no such hazard.

Now, let's take a similar approach to teaching another subject with far reaching safety implications, runway incursion accidents.

Lesson Plan (Example 3)

1. Type of training: **Safety/recurrent**

2. Maneuver or training objectives: **Provide student with the tools needed to reduce chances of a runway incursion incident/accident.**

3. Possible hazards and considerations (These examples are provided for training purposes only. Items may be added or omitted as necessary to reflect your unique operation.):

- **a. Airport/runway configuration**
- **b. Airport Surface Detection Equipment (ASDE)**
- **c. In cockpit moving map**
- **d. Towered versus non-towered airport**
- **e. Radio versus non-radio equipped aircraft**
- **f. Frequency congestion**
- **g. Traffic volume**
- **h. Single pilot versus crew operation**
- **i. Visibility/weather**
- **j. Approach obstructions**
- **k. Runway hold short lighting**
- **l. Pilot familiarity with airport**

4. Mitigation strategies and resources (Every hazard or consideration should be addressed though the use of some mitigating strategy or resource. Those provided below serve only as an example to illustrate system safety methodology.):

Airport/runway configuration: Potential hazards in the airport environment are numerous, and an airport's configuration is something that must be considered in any risk analysis. For example, if the taxiway layout requires the crossing of one or more active runways, this certainly increases the chances of a runway incursion. Also, if the airport has intersecting runways that are in simultaneous use, land and hold short operations (LAHSO) may be in effect. This too is an additional consideration for which a pilot must be prepared.

To mitigate potential risks, the pilot should begin by thoroughly studying the airport layout prior to departure. In addition, the pilot must make certain to verify all clearances prior to movement on the airport surface. Finally, pilots should avoid, to the extent possible, multitasking during critical operations. For example, during single pilot operations, the pilot should not attempt to copy a clearance or program their GPS while taxiing. "Heads down" time while moving creates a serious risk, but it is one that pilots can easily avoid by adopting safe operating practices.

Airport Surface Detection Equipment (ASDE): Technology can also help to mitigate potential risks. For example, some larger airports have control towers equipped with ASDE, which allows air traffic personnel to view the airport environment in great detail. The ability to monitor ground traffic may help controllers to stave off potential danger. However, because ASDE is a risk mitigating technology that is beyond the pilot's ability to control, it may not be relied upon rely to counter other hazards identified in this section. Students and instructors should become familiar with ASDE, the goal being to better understand the capabilities and limitations of the air traffic control system.

In-cockpit moving map: Unlike ASDE, an in-cockpit moving map display is an excellent risk control measure, one that can play a significant role in improving safety. The level of situational awareness afforded by such a system can reduce workloads substantially, even in a single-pilot environment. However, it is important to note that moving map displays are no substitute for thorough preflight planning. Pilots should be warned not to become complacent, and to avoid prolonged "heads down" time when using such a system. This may be avoided by proper equipment familiarization and the use of standard operating procedures.

Towered versus non-towered airport: Assessing the risks associated with a towered versus a non-towered airport can be extremely difficult. This is due in no small part to the tremendous number of variables involved. For example, a towered field will provide air traffic services, but this advantage may be offset by increases in traffic levels, frequency congestion, and pilot workload. A towered airport may also have a more complex runway and/or taxiway configuration, thus presenting greater hazards.

A non-towered field may have reduced traffic, however, airport signage and runway makings may not meet federal guidelines. There is also no ground controller to help direct you along the airport surface or to resolve potential traffic conflicts. Moreover, because most non-towered airports are smaller than their towered counterparts, it may be more difficult to find detailed diagrams depicting runway and taxiway layouts.

In most cases, hazards presented by the airport operating environment can be virtually eliminated by the pilot in command using previously cited strategies and techniques. These include thorough preflight planning, familiarization with aircraft equipment, the use of standardized operating practices, vigilance, and the verification of issued clearances.

Radio versus non-radio equipped aircraft: A functioning radio is one of the most valuable pieces of safety equipment available to any pilot. This is particularly true when operating on or near an airport. To maximize a radio's value in reducing risk, pilots need only use their radios consistently and in a professional manner to request and/or verify clearances, communicate with other pilots, and question any situation that does not appear to be safe. For pilots in non-radio equipped aircraft, vigilance and a strict adherence to right of way rules must be observed to reduce the risk of runway incursions.

Frequency congestion: Frequency congestion can be an issue at both towered and non-towered airports. However, most hazards come as a result of intense radio traffic in a towered airport environment. In these cases, the first mitigation strategy involves patience. To reduce the danger to you and other pilots, use proper radio etiquette. Listen before transmitting, and do not “step on” a transmission in progress, or break into an exchange between the controller and another pilot. Also, even if it takes additional time, make certain to read back all clearances prior to getting underway. If you are uncertain about a clearance or have any questions, take the time to ask *before* crossing the hold short line.

Air traffic facilities often mitigate risk during busy operations by dividing clearance delivery and ground control functions. If this is not the case, or it appears as though the local or ground controller is working more than one position, it is even more imperative that you visually confirm adequate traffic separation and verify any clearances that seem inappropriate.

Traffic volume: Increased traffic often compounds other risks discussed in this section. For example, with increased traffic often comes greater frequency congestion, greater opportunity to miss important air traffic instructions, not to mention a larger number of objects in which to come in contact. A look back to the risk assessment matrix will reflect greater (potential) frequency and severity associated with increased traffic volume. However, while increased traffic may pose some additional hazards, it shouldn’t be (and usually isn’t) the type of issue that would preclude a given flight. Pilots must simply be aware that increased traffic often demands greater vigilance, and the consequences of lost situational awareness may be greater. Again, thorough preflight planning, familiarization with aircraft equipment, the use of standardized operating practices, vigilance, and verification of issued clearances are the best ways to reduce risk.

Single pilot versus crew operation: As with most flight operations, the addition of a second crewmember serves as a significant risk control measure. Previous discussions focused on techniques for reducing hazards in a single pilot environment. When flying in a crew-served cockpit, each pilot must be certain they understand their duties, and that both adhere to agreed upon operating procedures when conducting their duties. Most important, even if only one crewmember has a question concerning a clearance or instruction, both must agree to resolve the issue to the satisfaction of both before continuing.

Visibility/weather: Any time visibility is reduced, the risk of a runway incursion increases. Traffic, runway markings, and airport signs all become more difficult to see under these conditions. In addition, pilot workload is usually increased, and attention may be focused on other cockpit duties. All of this can lead to a loss of situational awareness. Since all runway incursions have potentially catastrophic results, risk can only be reduced by lowering the probability of an occurrence. As in the cases above, thorough preflight planning, familiarization with aircraft equipment, the use of standardized operating practices, vigilance, and the verification of issued clearances are the best risk control measures.

Approach obstructions: Unlike several items on this list that are merely considerations, obstructions in the airport environment may prove a significant hazard. More often a problem at non-towered fields, obstructions increase the risk of a runway incursion by limiting ground-based traffic's line of site. In some cases, a pilot preparing to depart could taxi onto a runway, only to find an aircraft on final emerging over a line of trees. Proper radio use by all involved can reduce the risk of such an event. The use of proper standard operating procedures may also prove valuable in reducing risk. After thoroughly clearing the approach area, make certain that all pre-departure cockpit duties have been completed. This will reduce the need to spend a prolonged periods of time sitting on an active runway.

Runway hold short lighting: Like ASDE, this too is a risk control measure that may offset hazards such as reduced visibility or a pilot's lack of experience at a particular airport. Also, even during periods of increased workload, most runway hold short lighting systems will easily grab any pilot's attention. Like ASDE, these lighting systems address the frequency (probability) portion of the risk assessment matrix, but not the severity. Therefore, while they may improve the overall safety picture, it is still best to consider this in concert with other measures or strategies designed to reduce overall risk.

Pilot familiarity with airport: Familiarity with one's environment certainly offers advantages that reduce workload and lower risk. However, in an instructional exercise, students may be more impressed by the additional hazards created by a lack of familiarity. A failure to address airport familiarity as part of the preflight planning process multiplies the risks associated with other hazards. For example, the risk of a runway incursion increases during periods of reduced visibility, and a pilot's unfamiliarity with the airport further amplifies the probability of such an event. Because severity is a variable that remains nearly constant when discussing runway safety, inadequate preflight planning automatically increases risk.

5. <u>Alternatives</u>:

Note- While it is unlikely that any of the cited risks or hazards would require the listed alternatives, these should be presented to students to reinforce the idea that options are always available to reduce risk. For example, students should know that if they are issued a LAHSO clearance, they have the option to refuse and wait for an amended clearance.

Time: When planning a training exercise, time is always a variable to consider. For example, the pilot and/or instructor may determine that based on forecast weather conditions, it would be prudent to delay a training exercise (or other mission) until the winds, ceiling, or visibility improve.

Location: If airport conditions do not allow the planned training or operational exercise to be conducted safely, another venue should be chosen. This flexibility should be stressed during the planning/instructional process.

Abort training exercise: This alternate is included to emphasize there are times when aborting a flight or choosing not to perform a particular maneuver or operation is an appropriate and prudent course of action.

6. Requisite skill sets: Proficiency in basic aircraft operations; knowledge of airport signage, markings, and radio communication procedures.

7. Scenario-based training methodology: **The instructor will integrate two or more of the identified hazards into a cross-country flight operation. The choice of hazards will be made so as to realistically highlight risks likely encountered under similar circumstances. This will force the student to use both mechanical and cognitive skills in a dynamic environment- one that contains the distractions, challenges, and potential hazards found in a typical GA mission.**

8. Training materials: **AF/D, *Aeronautical Information Manual*, State Department of Transportation airport guides, online taxiway diagrams available through the Air Safety Foundation (available on-line at** http://www.aopa.org/asf/taxi**), AC 90-42, AC 91-73, etc.**

As you can see, each of the lesson plans developed in this series stress the tenets of system safety. Students are taught to carefully evaluate their operating environment with an eye toward identifying hazards (item 3 of the lesson plan). Each hazard is then studied to determine likelihood and severity, two variables in the risk equation (item 4 of the lesson plan). Then, using all available resources, a mitigation strategy is developed for each risk. After collectively reviewing all remaining issues; a determination is made on if and how best to continue the flight. If the risks cannot be lowered to acceptable levels, an alternative (item 5 of the lesson plan) must be considered.

Also, in reviewing this section, it is worth noting that no mention is made of developing a specific lesson covering judgment and aeronautical decision-making. This is because no such lesson is needed. Judgment and aeronautical decision-making are an integral part of each instructional exercise. As a result, there is simply no need to teach it as a stand-alone topic. In fact, it is difficult to imagine these subjects being taught effectively outside the context of an actual training scenario.

Conclusion

General aviation pilots enjoy a level of responsibility and freedom unique in the world of flight. Unlike the air carrier, corporate, and military communities, most GA pilots are free to fly when and where they choose. They are unencumbered by the strict regulatory structure that governs many other flight operations. However, the GA pilot is also not supported by a staff of dispatchers, meteorologists, or governed by rigid operational guidelines designed to reduce risk. The decision if or when to undertake any flight lies solely with the pilot in command. Preparing clients to meet this awesome challenge is the role of a professional flight instructor. As you go forth and apply what you have learned, here are a few last points of emphasis that may be of value to your clients.

Don't be lulled into a false sense of security simply because you are in compliance with the regulations. For example, take the VFR pilot who presses on into deteriorating weather conditions. We all know the dangers of continuing such operations into instrument conditions. However, consider that such a pilot was operating legally, right up to the point at which he or she entered instrument conditions. Remember, regulatory compliance is not the final step toward achieving safety; it is only the first. System safety emphasizes a compliance "plus" approach. Judgment and aeronautical decision-making will serve as the bridge between regulatory compliance and safety.

In closing, there is no question that bringing system safety to GA will require a higher level of preparation on the part of many flight instructors. However, the analytical thinking promoted by system safety will help make you a better instructor, your clients better pilots, and will help to significantly reduce the chances of becoming involved in a serious incident or accident.

To view other valuable training resources, please visit http://www.faa.gov/avr/afs/FITS.